

MICROPLATE STORAGE APPARATUS AND METHOD

FIELD OF THE INVENTION

[0001] The present invention relates generally to storage devices. More particularly, the present invention relates to microplate storage devices.

BACKGROUND OF THE INVENTION

[0002] Determining and achieving the proper conditions that allow a protein to crystallize from solution often requires many attempts before the proper concentrations of protein and reagents is determined and achieved. Furthermore, even when the conditions permit crystallization, the rate of crystallization is often very slow, at times on the order of weeks or even months. As a result, manually performing protein crystallization experiments is a very labor and time intensive process. One method of increasing the chances of obtaining protein crystals in the first experiment, thus saving a significant amount of time, is to try as many different protein and reagent concentrations as possible in the initial experiment.

[0003] Because protein crystallization experiments have traditionally been carried out in microplates, microplate storage hotels have been developed to store the numerous microplates prepared during the course of the experiment. Furthermore, because the preparing of the vast number of microplates and the periodic checking of each microplate for protein crystals are so labor intensive, automated protein crystallizers have been developed. These automated protein crystallizers are capable of utilizing multiple microplate storage hotels to increase the number of conditions that can be tested in a single experiment. The multiple microplate storage hotels of an automated protein crystallizer provide high

density storage of microplates, but also make up a significant fraction of the total cost of the crystallizer.

[0004] One problem when constructing complex, automated instruments using multiple microplate storage hotels is the need to know where each hotel and microplate is positioned, as well as the hotel's alignment and registration relative to other hotels and to the system frame. This information is required to facilitate the proper automated loading and unloading of microplates by a robotic plate handler from the microplate storage hotel. If the microplate storage hotel is not properly positioned, then the robotic plate handler cannot properly engage the microplates in the hotel.

[0005] Accordingly, it is desirable to provide a low cost microplate storage hotel. It is also desirable to provide a way to determine the position, alignment and registration of the microplate storage hotel.

SUMMARY OF THE INVENTION

[0006] The foregoing needs are met, to a great extent, by the present invention, wherein in some embodiments an apparatus is provided that integrates a plurality of shelving members and locating members with a pair of side panels for the construction of a microplate storage hotel. In addition, in some embodiments of the invention the microplate storage hotel has a base plate with integrated features that provide hotel position, alignment and registration information.

[0007] In accordance with one embodiment of the present invention, a side panel is provided. The side panel has a plurality of integrated shelving members, a plurality of integrated locating members flanking the shelving members, and an integrated locking flap located on the top of the side panel, that

are formed from one contiguous piece of material. In some embodiments of the invention, the side panel is connected to a base plate having both a positioning slot and an alignment slot.

[0008] In accordance with another embodiment of the present invention, a method for fabricating the side panel is provided. The method includes laser cutting the shelving member and locating members onto the side panel at the same time from a single template, and then folding the cut portions of the side panel to form shelving members and locating members.

[0009] In accordance with another embodiment of the present invention, a method for determining the storage unit's position is provided. The method includes locating the right edge of the positioning slot associated with the storage unit, locating the left edge of the positioning slot associated with the storage unit, and locating the top edge of the positioning slot associated with the storage unit.

[0010] In accordance with another embodiment of the present invention, a method for aligning and registering the storage unit is provided. The method includes fitting an alignment bar into an alignment slot on the base plate, and then scanning a barcode located on the surface defining the positioning slot on the base plate.

[0011] In accordance with another embodiment of the present invention, a side panel is provided. The side panel includes an integrated means for shelving objects and an integrated means for locating the objects on the shelves. The side panel further includes an integrated means for locking the side panels in place, a means for attaching side panels to a base plate to form a storage unit, a means for determining the storage unit's position, and a means for determining the storage unit's alignment and registration.

[0012] There has thus been outlined, rather broadly, certain embodiments of the invention in order that the detailed description thereof herein may be better understood, and in order that the present contribution to the art may be better appreciated. There are, of course, additional embodiments of the invention that will be described below and which will form the subject matter of the claims appended hereto.

[0013] In this respect, before explaining at least one embodiment of the invention in detail, it is to be understood that the invention is not limited in its application to the details of construction and to the arrangements of the components set forth in the following description or illustrated in the drawings. The invention is capable of embodiments in addition to those described and of being practiced and carried out in various ways. Also, it is to be understood that the phraseology and terminology employed herein, as well as the abstract, are for the purpose of description and should not be regarded as limiting.

[0014] As such, those skilled in the art will appreciate that the conception upon which this disclosure is based may readily be utilized as a basis for the designing of other structures, methods and systems for carrying out the several purposes of the present invention. It is important, therefore, that the claims be regarded as including such equivalent constructions insofar as they do not depart from the spirit and scope of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] FIG. 1 is a side view of an automated plate storage and imaging apparatus for protein crystallization in accordance with an embodiment of the invention.

[0016] FIG. 2 is a top view of the automated plate storage and imaging apparatus for protein crystallization shown in FIG. 1.

[0017] FIG. 3 is an isometric view illustrating a microplate storage hotel in accordance with an embodiment of the invention.

[0018] FIG. 4 is a side view of the microplate storage hotel shown in FIG. 3.

[0019] FIG. 5 is a front view of the microplate storage hotel shown in FIG. 3.

[0020] FIG. 6 is an isometric view of a side panel of the microplate storage hotel in accordance with an embodiment of the invention.

[0021] FIG. 7 is a side view of the side panel of the microplate storage hotel shown in FIG. 6.

[0022] FIG. 8 is a front view of the side panel of the microplate storage hotel shown in FIG. 6.

[0023] FIG. 9 is an isometric view of a base plate of the microplate storage hotel in accordance with an embodiment of the invention.

[0024] FIG. 10 is an isometric view of a top plate of the microplate storage hotel in accordance with an embodiment of the invention.

DETAILED DESCRIPTION

[0025] The invention will now be described with reference to the drawing figures, in which like reference numerals refer to like parts throughout. An embodiment in accordance with the present invention provides a way to store microplates in a high density and cost effective manner in a complex instrument. Furthermore, some embodiments also provide a way to determine the position,

alignment and registration of a microplate storage hotel relative to other hotels and to the instrument's frame.

[0026] FIG. 1 shows a side view of an automated plate storage and imaging apparatus 20 for protein crystallization. The apparatus 20 has a system frame 22 that supports the housing of multiple microplate storage hotels 24. A robotic microplate handler 26 shown in FIG. 2, controlled by a computer system 28, is used to transfer a microplate 30 to the imager 32. The computer system 28 has a monitor 34 and is used to analyze the data collected by the imager 32. The imager 32 can take images under brightfield, darkfield, and polarized illumination, that can then be analyzed by the computer system 28 for the detection and characterization of protein crystals. The imager 32 can be a charge-coupled device (CCD) camera or other optical, or non-optical imaging device. The computer system 28 is fully programmable to analyze the microplates 30 in any particular order at any defined times. This makes it very simple to determine protein crystal growth kinetics by analyzing a microplate 30 over a period of time.

[0027] As shown in FIG. 1, the microplate storage hotels 24 can be stored adjacent to each other in a highly dense configuration on the system frame 22. This allows for a large number of microplates 30 to be stored in a relatively small amount of space, saving valuable laboratory space for other instruments or other purposes.

[0028] FIG. 3 is an isometric view of one embodiment of a microplate storage hotel 24. The hotel 24 has two parallel side panels 36 and 38, that are identical to each other. Each side panel 36 and 38 can serve as either the left or right side panel 36 and 38. The two parallel side panels 36 and 38 are connected at one end to a base plate 40 and at the other end to a top plate 42. The connections may be formed by using a rivet, nut and bolt, screw, nail, other

mechanical means, welding with solder, welding without solder, arc welding, spot welding, torch welding, other welding means, glue, epoxy, resin, other adhesive means, or by another suitable means to connect objects together. The side panels 36 and 38, base plate 40, and top plate 42 can be constructed out of metal, plastic, wood, or another material suitable for construction purposes. In one embodiment, the side panels 36 and 38 are made of stainless steel while the base plate 40 and top plate 42 are made of aluminum.

[0029] The side panels 36 and 38 have both a plurality of integrated shelving members 44 and a plurality of integrated locating members 46 and 48, which function to hold the microplate 30 (see FIG. 1) and align the microplate 30 in a shelving slot 50, respectively. The integrated locating members 46 and 48 have surfaces 52 (see FIG. 6) positioned at approximately 45 degree angles that help guide the microplate 30 into a shelving slot 50 defined by the shelving members 44 and the side panels 36 and 38. Inserting a microplate 30 into the microplate storage hotel 24 is accomplished by inserting the microplate 30 between the locating members 46 and 48 into the desired shelving slot 50. The locating members 46 and 48 help center the microplate 30 in the shelving slot 50 if the microplate 30 is initially misplaced.

[0030] The integrated shelving members 44 are laser cut and punched from the side panels 36 in a manner that results in a row of horizontal shelving members 44 that project into the interior of the microplate storage hotel 24. The integrated locating members 46 and 48 flanking the shelving members 44 are laser cut and punched at the same time as the shelving members 44 from a single template which enhances the precision of the final shelving assembly. The technique of fabricating the integrated shelving members 44 and locating members 46 and 48 is not limited to laser cutting; other fabrication techniques

such as mechanically cutting or stamping out the shelving members 44 and locating members 46 and 48 are in accordance with the invention.

[0031] The base plate 40 has a positioning slot 54 that allows the microplate storage hotel's 24 position to be determined with a sensor on the robotic microplate handler 26 (see FIG. 2) that locates either the left edge 56 of the positioning slot 54 or the right edge 58 of the positioning slot 54, and the top edge 60 of the positioning slot 54. Because the positioning slot 54 is both centered on the base plate 40 and made in one width for various embodiments of the hotel 24, the locations of one side edge 56 or 58, and the top edge 60 are sufficient for the sensor on the robotic microplate handler 26 in conjunction with the computer system 28 (see FIG. 1) to determine the position of the microplate storage hotel 24.

[0032] The side panel 36 has an integral locking flap 62 that serves as both a mechanism to lock the microplate storage hotel 24 into place when set in the automated plate storage and imaging apparatus 20 (see FIG. 1) and as an attachment point 64 for a handle 66. The handle 66 can be made of steel, aluminum, another metal or metal alloy, plastic, or another suitable material. The locking flap 62 is engaged by a locking mechanism on the system frame 22 (see FIG. 1).

[0033] FIG. 4 shows a side view of one embodiment of the microplate storage hotel 24. The locating members 46 and 48 on the side panels 36 are slanted towards the shelving members 44, and this helps align the microplates 30 (see FIG. 1) on the shelving members 44. A precise positioning of the microplates 30 on the shelving members 44 is necessary for the automated removal and insertion of microplates 30 from the microplate storage hotel 24. Also shown in this figure is the locking flap 62 and handle attachment point 64.

Bolts, screws, nails, rivets, welding, or another suitable method can be used to attach the handle 66 to the handle attachment point 64. The two bottom attachment points 68 on the side panel 36 connect the side panel 36 to the base plate 40, while the two top attachment points 70 on the side panel 36 connect the side panel 36 to the top plate 42 depicted in FIG. 3. Bolts, rivets, another mechanical means, welding, or an adhesive can be used at the attachment points 68 and 70.

[0034] On the bottom of the base plate 40 is an alignment slot 72. This slot 72 is mated to a corresponding alignment bar located on the system frame 22 (see FIG. 1) to align the microplate storage hotel 24 with the system frame 22. When the alignment bar is fitted into the alignment slot 72, the microplate storage hotel 24 is oriented in the proper direction. After alignment, a sensor on the robotic microplate handler 26 (see FIG. 1) is able to read a barcode 74 located on the base plate 40 depicted in FIG. 3 in order to register the microplate storage hotel 24. Microplate storage hotel 24 registration allows the automated plate storage and imaging apparatus 20 (see FIG. 1) to know what type of microplate storage hotels 24 are being used, and furthermore, registration allows the user to program into the computer system 28 (see FIG. 1) customized information regarding each microplate storage hotel 24 and the microplates 30 stored in the hotel 24.

[0035] FIG. 5 shows a front view of one embodiment of the microplate storage hotel 24. As shown in FIG. 5, the shelving members 44 project horizontally from the side panels 36 and 38 into the interior of the microplate storage hotel 24 and provide a support for the right and left edges of a microplate 30. The amount of support provided to a microplate 30 (see FIG. 1) can be increased or decreased by varying how far the shelving members 44 project into

the interior of the microplate storage hotel 24. The further the shelving member 44 projects into the interior of the microplate storage hotel 24, the more the support that is provided to the microplate 30. The vertical gap between a corresponding pair of shelving members 44, allows the robotic microplate handler 26 (see FIG. 2) to be inserted slightly under the microplate 30, lifted until contact is made with the bottom of the microplate 30, lifted further to separate the microplate 30 from the shelving members 44 and to clear the locating members 46 and 48 (see FIGS. 3 and 4), and finally for the microplate 30 to be removed from the microplate storage hotel 24.

[0036] Insertion of a microplate 30 (see FIG. 1) into the microplate storage hotel 24 occurs in the reverse order as microplate 30 removal. The robotic microplate handler 26 (see FIG. 2) carrying the microplate 30 is inserted into the shelving slot 50 of the microplate storage hotel 24 by a horizontal insertion above the locating members 46 and 48, then lowered until the microplate 30 rests upon the shelving members 44. The robotic microplate handler 26 is then lowered to remove contact with the microplate 30, and finally removed from the microplate storage hotel 24. If the microplate 30 is misplaced into the shelving slot 50 so that one edge of the microplate 30 rests upon a pair of locating members 46 and 48, the microplate 30 will tend to slide down the angled locating members 46 and 48 until it properly rests upon the shelving members 44 in the shelving slot 50.

[0037] As can be seen in FIG. 5, insertion and removal of microplates 30 can occur from both the front and back of the microplate storage hotel 24 because there is no obstruction of either the front entrance or back entrance; therefore the microplate storage hotel 24 is pass-through capable. This allows the robotic

microplate handler 26 (see FIG. 2) access to one side of the microplate storage hotel 24 and manual access from the other side of the microplate storage hotel 24.

[0038] Also visible in FIG. 5 is the positioning slot 54 which is located on the front of the base plate 40.

[0039] FIG. 6 is an isometric view of the side panel 36 that shows that the shelving members 44, the locating members 46 and 48, and the locking flap 62 are all integrated into to the side panel 36. Furthermore, FIGS. 6 and 7 show the location of the two bottom attachment points 68 and the two top attachment points 70. As mentioned above, the one-piece construction of the side panel 36 results in precision and reproducibility in terms of shelving member 44 position and alignment, as well as precision and reproducibility of locating member 46 and 48 position and alignment. Because the automated insertion and removal of microplates 30 (see FIG. 1) from the microplate storage hotel 24 (see FIG. 1) is facilitated by accurate positioning of the microplates 30 in the hotel 24, this integration of features in the side panel 36, along with the integrated features of the base plate 40 that are shown in detail in FIG. 9, enhances the overall performance of the microplate storage system and reduces the possibility of a machine failure during the insertion and removal process.

[0040] FIG. 7 provides a side view and FIG. 8 provides a front view of the side panel 36. FIG. 8 shows the locating members 46 and 48 slanted approximately at a 45 degree angle. However, other slant angles are also suitable and can be used in accordance with an embodiment of the invention.

[0041] FIG. 9 shows an isometric view of the base plate 40 with the positioning slot 54 at the top of the figure and the alignment slot 72 running across the middle. Four base plate 40 attachment points 76 that connect the base plate 40 with the side panels 36 and 38 (see FIG. 3) are visible in FIG. 9. Also

visible are the four stationary attachment points 78 that serve to anchor the microplate storage hotel 24 (see FIG. 3) in a fixed position. The stationary attachment points 78 are used when the microplate storage hotel 24 will not be moved during the operation of the automated plate storage and imaging apparatus 20 (see FIG. 1). Nuts and bolts can be used to fasten the base plate 40 to the system frame 22 (see FIG. 1).

[0042] Also shown are the three edges 56, 58 and 60 of the positioning slot 54 that are used to determine the microplate storage hotel's 24 position in space: the left edge 56 of the positioning slot 54, the right edge 58 of the positioning slot 54, and the top edge 60 of the positioning slot 54. For example, in one embodiment of the invention an optical sensor located on the robotic microplate handler 26 (see FIG. 2) can be used to locate either the left edge 56 or right edge 58 of the positioning slot 54, and then the top edge 60 of the positioning slot 54. Then the information collected by the optical sensor can be analyzed by a computer system 28 (see FIG. 1) to determine the microplate storage hotel's 24 position in space.

[0043] The alignment slot 72 shown in FIG. 9 runs across the middle of the bottom face of the base plate 40. A corresponding alignment bar in one embodiment of the invention fits into the alignment slot 72 to align and the microplate storage hotel 24 (see FIG. 1) with respect to other microplate storage hotels 24 and the system frame 22 (see FIG. 1).

[0044] FIG. 9 shows the front base plate hollow 80 and the rear base plate hollow 82 which serves to decrease the weight of the base plate 40, and in some embodiments of the invention, to decrease the amount of material needed to construct the base plate 40.

[0045] FIG. 10 shows an isometric view of the top plate 42. Like the base plate 40 depicted in FIG. 9, the top plate 42 also has a hollow 84 that functions to decrease the weight of the top plate 42, and in some embodiments of the invention, to decrease the amount of materials needed to construct the top plate 42. Finally, four top plate 42 attachment points 86 that connect the top plate 42 with the side panels 36 and 38 (see FIG. 3) are shown.

[0046] Although an example of the microplate storage hotel 24 (see FIG. 1) is shown using microplates 30 (see FIG. 1), it will be appreciated that other objects can be stored in the hotel 24. Also, although the microplate storage hotel 24 is useful to store microplates 30 at high densities, it can also be used store other objects at high densities in a cost effective manner.

[0047] The many features and advantages of the invention are apparent from the detailed specification, and thus, it is intended by the appended claims to cover all such features and advantages of the invention which fall within the true spirit and scope of the invention. Further, since numerous modifications and variations will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation illustrated and described, and accordingly, all suitable modifications and equivalents may be resorted to, falling within the scope of the invention.

What is claimed is:

1. A side panel comprising a plurality of integrated shelving members, and a plurality of integrated locating members flanking both sides of the shelving members and slanted towards the shelving members, that are formed from one contiguous piece of material.
2. The side panel of claim 1, further comprising an integrated locking flap.
3. The side panel of claim 1, and a second side panel arranged in a mirror image to the first side panel, further comprising a base plate that is attached to the bottom of both the first side panel and the second side panel to form a storage unit.
4. The side panel of claim 3, wherein the first side panel is substantially identical to the second side panel.
5. The side panel of claim 3, wherein the storage unit further comprises a top plate attached to the top of both the first side panel and the second side panel.
6. The side panel of claim 3, wherein the storage unit further comprises a positioning slot in the base plate.
7. The side panel of claim 3, wherein the storage unit further comprises an alignment slot in the base plate.

8. The side panel of claim 3, wherein the storage unit further comprises a shelving slot defined by two adjacent shelving members and both side panels, with an opening to both the front and back of the storage unit.
9. The side panel of claim 3, wherein the storage unit further comprises an integrated locking flap at the top of each side panel.
10. The side panel of claim 9, wherein the storage unit further comprises a handle attached to the locking flaps.
11. The side panel of claim 3, wherein the storage unit further comprises:
a top plate attached to the top of both the first side panel and the second side panel;
a base plate with both a positioning slot and an alignment slot; and
side panels with integrated locking flaps.
12. The side panel of claim 11, wherein the storage unit further comprises a base plate and top plate with internal hollow spaces.
13. The side panel of claim 11, wherein the side panel is comprised of stainless steel, the base plate is comprised of aluminum, and the top plate is comprised of aluminum.
14. A method for fabricating the side panel comprising the steps of:
cutting the shelving members and locating members onto the side panel from a single template; and

folding the cut portions of the side panel to form shelving members and locating members.

15. The method of claim 14, wherein the cutting is accomplished with a laser.

16. The method of claim 14, wherein the cutting of the shelving members and locating members is done at the same time.

17. A method for determining the storage unit's position comprising the steps of:

locating one side edge of the positioning slot associated with the storage unit; and

locating the top edge of the positioning slot associated with the storage unit.

18. A method for aligning and registering the storage unit comprising the steps of:

fitting an alignment bar into an alignment slot on the base plate; and
scanning a barcode on the base plate.

19. The method of claim 18, where the barcode is located proximate to the positioning slot.

20. A side panel comprising an integrated means for shelving objects and an integrated means for locating the objects on the shelves that flank and slant towards the means for shelving.

21. The side panel of claim 20, further comprising an integrated means for locking the side panels in place.

22. The side panel of claim 20, further comprising a means for attaching a first side panel and a second side panel to a base plate to form a storage unit.

23. The side panel of claim 22, wherein the storage unit further comprises a means for determining the storage unit's position.

24. The side panel of claim 22, wherein the storage unit further comprises a means for determining the storage unit's alignment and registration.

25. The side panel of claim 22, wherein the storage unit further comprises a means for accessing the storage unit from both the front and back sides of the storage unit.